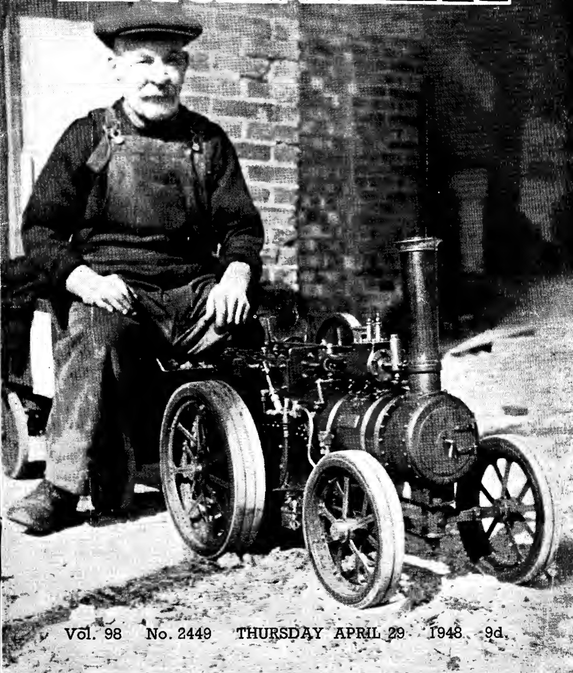
THE MODEL ENGINEER



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The MODEL ENGINEER

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GREETING AND FAREWELL

"P.M."—1870-1948

THE quality that makes a man memorable takes many different forms. Eminence in the big affairs of the world; distinguished work in science, law, or the arts; heroic action in an hour of danger; statesmanship, administrative ability, even the dull power of accumulating money, may raise his name above the common level. But there is another and kindlier fame that wins no headlines in the daily press; it shines, nevertheless, with a steady light, clear and unmistakable and inspiring. It is a quality of life, endearing and enduring—the gift of making friends; and that gift Percival Marshall possessed in the highest degree. He did great and lasting work in a special field of engineering which he made his own; yet we who knew him and talked with him day by day would set an equal value upon that genius for friendship which was the outstanding characteristic of his personality and his career.

He gave, in the New Year's Day issue of this journal, something of the story of his life. Born in London on December 31st, 1870, his early training was in good hands, for the professors at the historic Finsbury Technical College, through which he passed, were men of mark in the 'eighties and 'nineties—many of them pioneers in electrical and mechanical engineering. He also attended courses of study at the Birkbeck Institute, the Manchester Technical School, and the Victoria University, afterwards gaining experience with several well-known firms as apprentice, improver, fitter and machinist. He spent some months as a lathe hand in a French factory. With a scholarship, technical diplomas, and other honours he considered that he was "all set" for the life of a skilled practical engineer.

The fates, however, had different views. Perhaps we should more correctly say that his own energy and decision steered him in a different direction. He had a definite desire to get his ideas down on paper, and like many another young man he found eventually that free-lance writing opened the way to an editorial chair; rather surprisingly, he became editor of a photographic magazine. Then the idea of starting a popular engineering paper captured him, and Percival Marshall, carrying that idea over many difficult hurdles, heeding no doleful prophets, published the first issue of his own monthly, the *Model Engineer and Amateur Electrician*, in January, 1898, when he was 27 years old. Warned that he would be lucky if he sold 500 copies; told that model engineering was "dying out"; he faced with his calm smile all the usual gloomy comments that enterprise attracts. The first two numbers sold out at once and had to be reprinted; and today the circulation of the "M.E." is counted in tens of thousands a week.

Thus, then, began the main theme of Percival Marshall's activities for the next fifty years, a theme with endless variations, delightful to himself and to his innumerable readers. His heart was in it, and if at any time he heard some derogatory remark that relegated model engineering to the toyshop level or attempted to lower its standing by limiting its scope to a passing amusement for boys, "P.M." would demolish such criticisms in one of his rare onsets of severity. In fact, this class of loose comment, still occasionally to be heard, was the one thing that could bring him as near to "blowing off" with the pressure of resentment as any of us have ever seen him. He was cross with it; it annoyed him; and he refuted it admirably, advancing argument after argument that left his opponent no escape. He would point out the vital part that model making plays in almost every scientific and industrial development, from the small "hook-up" of the laboratory to the giant tanks and wind-tunnels of the large-scale experimental test or the "mock-up" of a new type of aeroplane. But apart from this essential aspect, he would say, what about the sheer pleasure of building a beautiful bit of mechanism with one's own hands—the recreative aspect, as evidenced at THE MODEL ENGINEER Exhibition, where ships and clocks and engines of every kind in miniature, made by postmen and taxi-drivers and those interesting people known collectively as "ordinary," can be seen and admired?

How "P.M." loved this Exhibition! In the year that saw the birth of THE MODEL ENGINEER, he had founded also the Society of Model and Experimental Engineers, which has influenced the formation of over a hundred local clubs and societies with similar aims at home and abroad. The first Exhibition was held in October, 1907, and though for a time it was biennial it has become now a remarkably successful annual event, a rallying point for model enthusiasts everywhere, as all our readers know. There, amid the unique display of talent in true craftsmanship, "P.M." was "at home" indeed to a host of friends; and many of us remember with pleasure his happy little informal speech on the occasion of the 21st birthday of the Exhibition in 1946.

"P.M."

Although it is natural to lay strong emphasis on the work by which Percival Marshall was chiefly known, his other interests must be remembered. One of these was his early association with the Junior Institution of Engineers, to which he was elected in October, 1886, becoming a member of the then "Committee"—later the Council—in 1887, "at the age of 16.5." He held the office of Chairman of the Council for two years (1900-1902). But apart from engineering he did a great deal for technical journalism. This followed partly, no doubt, from his family link with publishing; he was a nephew of Sir Horace Marshall, K.C.V.O., P.C., J.P., M.A., LL.D., Governing Director of Horace Marshall and Son Ltd., who was Lord Mayor of London for the year 1918-19. Percival Marshall took a leading part in creating the British Association of Trade and Technical Journals, which later was amalgamated with the Periodical Trade Press and Weekly Newspaper Proprietors' Association. He was Executive Chairman of this larger body from 1928 to 1943, when he was elected vice-President. To this work he devoted much of his spare time, attending committee meetings regularly and being responsible for many suggestions affecting the well-being and prestige of technical journals in this country. For some years he served on the Council of the Empire Press Union, and, in kindred activities, made more than one visit to Canada and the United States. He had been a member of the Press Club for over 30 years, was a trustee of the Press Club Fund, and at one time lunched there almost every day, spending half-an-hour or so afterwards over a game of bridge in the card-room. In June, 1929, his own publishing business of Percival Marshall & Co., was by arrangement amalgamated with that of the Electrical Press Ltd., since when the two have been carried on successfully as a single organisation.

For the last few years he had relinquished the more onerous duties of editorship, leaving them in the hands of a loyal and competent staff which had carried on, and will continue to do so, the tradition so finely and firmly established by the leader they knew so well.

His recreations were such as one would expect in a man whose nature was tranquil, contemplative, and philosophic. Golf and fishing took first place; he was a prominent member of the London Press Golfing Society, and followed Bernard Darwin as captain in 1912; he was also an excellent shot, winning a silver cup at Bisley.

And now we have to say farewell ... to a pioneer, an engineer, a philosopher; a man upright physically and mentally; a man who was "valiant for friendship"; a man of wide experience and alert of thought. With quiet humour and kindly wit, Percival Marshall moved among us for many good years, smiling, encouraging, steadying, and it is hard to realise that we shall not see him again in the old familiar places. The farewell was unexpected, for though he had not looked thoroughly well of late he was busy at his letters—nearly always written with his own hand—and his charming "Smoke Rings" with his beloved pipe, almost to the last. He left his office early on March 12th, and did not return. The end came peacefully and without pain, on April 10th. To us he was always "P.M.," and we may close on a note of gratefulness that we have walked for a little way along the journey with one of whom it can be truly said, as of another pioneer, that, apart from his work, remains "that best portion of a good man's life, his little nameless and unnumbered acts of kindness and of love."

PETROL ENGINE TOPICS

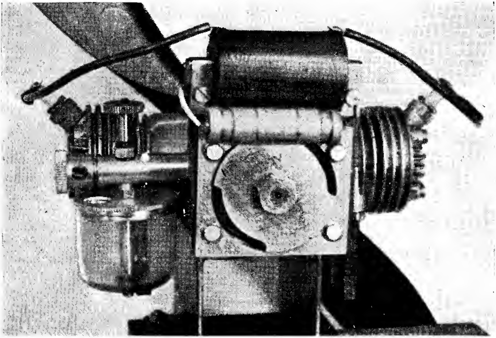
*A 10 c.c. Flat Twin Two-Stroke Engine

by Edgar T. Westbury

THE flywheel, illustrated in Fig. 16, is preferably made from mild steel, though a sound iron casting, or even brass or gunmetal may be used, if this is not available. Several variations in the design of the flywheel are permissible, and may be found desirable according to the application or duty for which the engine is required. The form shown is specially suited for use in a model racing car, as the flat front face enables the pivot studs of the centrifugal clutch to be fitted. For marine use, the same form of flywheel, with studs to take a flexible disc or other type of coupling, may be used ; but it is more common, in boat engines, to use a socket coupling, which may be screwed on to the shaft in place of the flywheel nut. It is also desirable, in this case, to make the starting pulley smaller in diameter than the flywheel, which makes it rather easier to apply the starting cord and also enables the engine to be spun faster. (An example of a suitable flywheel for this purpose may be seen in the drawings of the " Seal " engine.)

*Continued from page 411, " M.E.," April 15, 1948.

Machining procedure for the flywheel is quite simple, the method recommended being to chuck the blank or casting to rough-turn the front face and as much of the rim as possible, then reverse it to turn the back face, recess and hub spigot, and bore the centre. Final turning of the face and rim, also the starting groove, should be carried out by mounting the flywheel on a truly turned taper spigot—the collet may be used for this purpose, after turning the outside and before parting off—and this will ensure that all machined surfaces on the flywheel are concentrically true. It will be seen that the groove in the flywheel is cut to a fairly acute taper, not more than 40 degrees included angle, to give a good grip to the starting cord, which may be a piece of $\frac{3}{16}$-in. round belting or sash cord.



Rear view of engine with dual-spark " Atomag Minor " magneto fitted, showing also carburettor with bowl reservoir

Hub Collet (Fig. 17)

This component is combined with the contact-breaker cam, and is made of mild steel, which may, with advantage, be subsequently case-hardened. Constructors who doubt their ability to mate the internal and external tapers properly may resort to the old dodge of turning both at

the same slide-rest setting, but this method is not so "fool-proof" as is commonly believed, and will only result in a good fit if both the internal and external tools are set exactly at centre height, and all other precautions observed to ensure accuracy and high finish. About $\frac{1}{16}$ in. allowance for "draw" should be given when sizing the collet, and before parting off, it may be set eccentric for turning the cam surface, the use of a vee angle-plate being again recommended for this purpose. Neither the radius nor the angle embraced by the cam surface is critical. After parting off, a chamfer or radius should be machined in the mouth of the bore to enable the collet to go right home against the shoulder of the crankshaft. Finally the collet is split through its entire length, though the cam end may be left solid if desired, it will reduce the flexibility and the latitude of accommodation of the collet.

In the event of the engine being used to drive an airscrew, the hub for mounting the latter should preferably be made to take a collet in the same way as the flywheel, but quite a good drive has been obtained simply by making the hub a close parallel push fit on the shaft, and clamping up firmly with a nut and washer. I do not believe in "positive" drives which entail squares or flats on the shaft; I consider that the only sound drive of this type would be a serrated or multi-splined assembly, which is difficult to carry out properly and, I believe, quite unnecessary in a small engine.

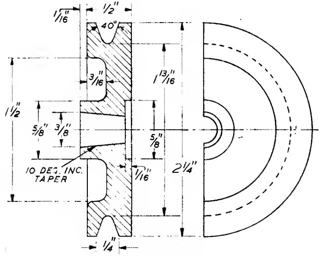


Fig. 16. Flywheel

Contact-Breaker

It has already been explained that a flat twin two-stroke requires special ignition equipment giving two sparks simultaneously. So far as the contact-breaker design is concerned, however, this does not necessarily have to be any different from that of a single-cylinder engine; this applies, no matter whether two separate ignition coils or a special double-spark coil, may be employed.

The form of contact-breaker shown in Figs. 18 and 19 is a development of the simple spring blade type which has been used successfully on earlier engines, and its operation, I think, will be readily understood without a detailed explanation. It embodies a bracket casting which is frictionally clamped to the front main-bearing housing, and the cross piece which carries the blade overhangs the front of the bearing so that its centre lies over the cam track on the flywheel hub. At this point a fibre push-rod is fitted which bears on the cam track and normally holds the blade out of contact with the contact screw except when the contour of the cam allows it to drop. The spring blade is insulated from the bracket by the fibre bushes, and the bolt which holds it in place forms the low-tension terminal.

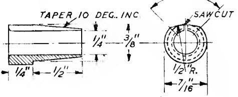


Fig. 17. Hub collet

Special tungsten-tipped contact screws and rivets are available for this contact-breaker; the screws are 6-B.A., with a slotted end and a lock nut for adjustment, and the rivets are made with a tail 1 mm. diameter which should fit the hole in the spring closely, so that they do not require an excessive amount of hammering down. Support the tip of the rivet on a pad of soft copper or aluminium to reduce risk of cracking it when riveting.

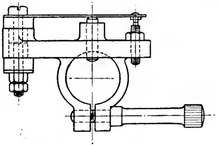


Fig. 18. Contact-breaker assembly

The spring is made of 20-gauge (or approximately 1/32 in. thick) spring steel, and, as shown in the drawing, is narrowed between the fixed end and the push rod to improve its flexibility. This is optional, but will be found to improve the action, and require less mechanical power to operate at high speed. On no account taper or

narrow down the contact end of the blade to "make it look nice!" The spring should be given a slight downward "set" to make sure that it gives a firm contact when approximately parallel with the bracket—its normal working position. It may be necessary to file the end of the push rod a little to get this right, but don't overdo things, as the push rod will bed down slightly as it gets run in, and this will cause the contacts to close up somewhat in the early stages of running. Normal contact clearance is about 0.005 in.

The push rod may be made of fine laminated fabric bakelite, such as Tufnol or Paxolin, and should be turned from rod or sheet material with the fibres running in the direction of the length. It should be quite an easy fit in the guide, as it may possibly swell slightly in damp weather, and any tendency to stick or move sluggishly will cause misfiring of the engine.

If desired, the contact-breaker assembly may be mounted on the rear housing, and a separate cam fitted to the shaft at this end to operate it. This arrangement may be more convenient in certain cases, as, for instance, when the engine is used for aircraft, and it is desired to keep the controls well away from the airscrew, to avoid risk of injury when operating them.

Instead of the usual clamping screw in the split lug of the contact-breaker bracket, an extended knurled screw is fitted, which serves as a control lever, and enables the lug to be tightened to lock the timing adjustment when once set under running conditions.

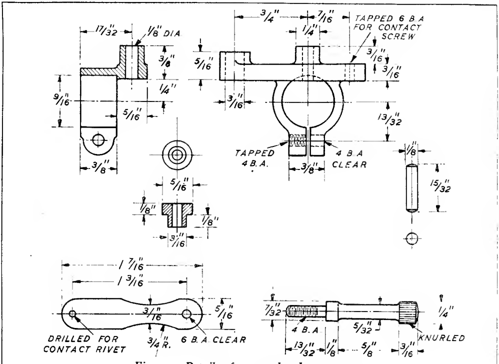


Fig. 19. *Details of contact-breaker components*

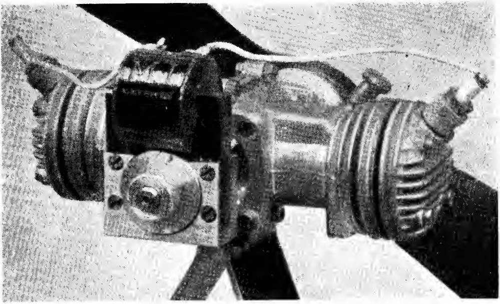
Ignition Coils

When two separate coils are used for ignition, they should be of the same type, or at least exactly matched in respect of voltage and current consumption. They are both operated from the same contact breaker, being wired in series with the points, and a single condenser is used across the latter as usual, though its capacity may possibly need to be modified to obtain best results. The coils may be connected either in parallel or in series with each other; in the former case, they run on normal voltage but take twice the current compared to a single coil; in the latter case, the current consumption is normal, but twice the voltage is required to energise the coils fully.

The use of a special form of coil, producing sparks at two poles, has several advantages over the use of two separate coils, including greater compactness and lower weight. A coil of this type was described in my articles on Ignition Equipment, published in THE MODEL ENGINEER a couple of years ago. (It may be in order to mention that these articles, with certain revision and abridgment, have now been produced in book form, and by the time these notes appear in print the book should be available from THE MODEL ENGINEER Publishing Department.) A dual-spark coil is also manufactured by Miniature Ignition and Accessories, under the name of the "Duomite" coil, and one of these coils has been successfully employed on the initial tests of the engine.

To those who prefer magneto ignition—and I, personally, have no doubts whatever as to its all-round advantages—there is also the choice between a home-made and a ready-made magneto. The original "Atomag Minor" design, as described in THE MODEL ENGINEER, has been successfully adapted to produce two simultaneous sparks, the only essential difference being that the secondary winding of the coil is completely practicable and in some respects preferable, to use the same contact-breaker as for coil ignition, mounted on the opposite end bearing housing.

I have designed a flywheel magneto well suited for use on this engine, and highly efficient, but have not been able to arrange for the supply magnets and other essential parts for it yet, so it would be injudicious, or at last somewhat premature, to describe it in detail.



Another engine fitted with "M.I." dual-spark miniature magneto, and oblique carburettor mounted on reverse end

insulated from the primary by a bakelite tube, and both ends of the windings brought out to the sparking-plug leads. This slightly lowers the magneto efficiency, especially at low speeds, by removing the auto-transformer coupling between primary and secondary; but the margin of efficiency in the "Atomag" is sufficient to allow for this, and the engine starts quite readily on the flywheel, though it is rather difficult to start with an airscrew. I am at present making experiments with a double section winding, which should effectively remove even this minor disadvantage.

The makers of the M.I. miniature magnetos have also produced a double-spark type which is lighter than the "Atomag" and which will probably be quite successful, though at the time of writing, I have not been able to complete arrangements for a thorough test of the sample submitted. In the case of either of these magnetos, they may be made as entirely separate units and direct-coupled or geared to the engine, or they may be made as an integral part of it, as shown in the photographs. The latter arrangement saves both weight and space, and is also more efficient mechanically. The "Atomag" illustrated has the contact-breaker built into the backplate by which it is mounted on the bearing housing, and operated from a cam cut on the shaft; but it is

To the many readers who have asked whether it is possible to convert the engine to a (so-called) "diesel," the answer is—yes, if you are prepared to build it to a still higher degree of precision than is necessary for running on petrol. Special heads, containing contra-pistons, would be necessary unless one is content to work at a fixed compression ratio (and from my experience with engines having no adjustment in this respect, I do not recommend this), and the synchronisation of the compression ratios in the two cylinders might be a somewhat delicate task, especially as the simultaneous firing makes it difficult to segregate the events in each separate cylinder. With spark ignition, alternate shorting-out of the plugs enables each cylinder to be tested separately. It is possible to interconnect the compression adjustment screws by gearing, so that they work together, but this is a somewhat ponderous and complicated business. I do not think the flat twin is the best type of engine for adaptation in this way, and I shall have some further observations to make on this matter shortly.

Many readers, also, have asked whether this type of engine will produce more power than a single-cylinder engine of the same cubic capacity. I cannot answer this definitely, as it is so difficult

(Continued on next page)

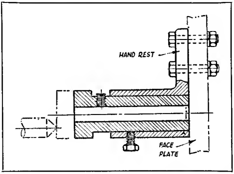
An Eccentric Turning Fixture

by H. J. Higgins

HAVING made a number of built-up, overhung crankshafts at various times for small I.C. engines, I had never felt quite satisfied with any of them.

To make a real good job, to my way of thinking, there is only one method, "machining from the solid." Being strong of heart, but weak in pocket, like many of my fellow model engineer enthusiasts, where was the eccentric turning fixture coming from?

Turning out the junk-box for anything that might suggest a way out, yielded a blank. But whilst sitting at my workbench, feeling like Bruce as he watched the spider, I noticed the "hand rest" belonging to the lathe. I said to myself: "That's it!"



Having removed the rest from its socket I found the hole to be ¾ in. diam. A piece of metal was then turned to this size, a good fit, with a shoulder of 1 in. diam. and ⅜ in. depth, this to give support to the web during turning operations, the piece of metal being ⅜ in. longer than the depth of the socket.

A hole was then drilled and reamed through the length of the metal 5/16 in. diam., this being the size of the journal for the crankshaft I was about to make. Afterwards a hole was drilled and tapped 2-B.A. to take a copper-ended bolt just below the shoulder to hold the journal firm and without damage.

The piece of metal was now inserted in the ¾-in. hole of the hand rest, and secured by the original height-adjusting screw.

The device was then temporarily fixed to the faceplate.

The blank having been previously turned and marked off for a crankshaft; journal 5/16 in. diam., a ⅜-in. throw, i.e. a ⅜-in. stroke was now bolted in the fixture and adjusted so that the crankpin's position could be determined on its scribed circle; this being done, a Slocombe drill was brought up in the tailstock and the crankpin position centred.

The back centre was then brought up to the crankpin centre, and the normal turning procedure followed.

As will be seen, crankshafts of varying journal diameter can be turned up by this simple device, by enlarging or reducing the hole in the metal insert. The set-up will be found to be quite rigid. And that cost of an eccentric turning fixture—Well, I ask you!

Petrol Engine Topics

(Continued from previous page)

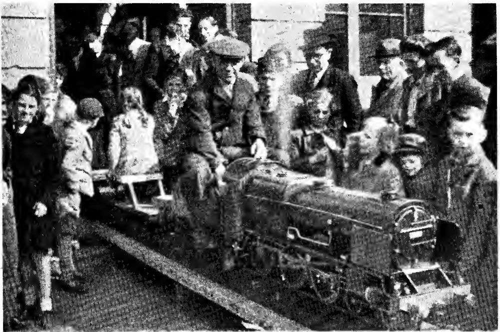
to obtain exact data for true comparison, but at the risk of disappointing them, I would say that the balance of probability is all against it. The mechanical efficiency of a small twin or multi-cylinder engine is bound to be lower than that of a single, and so far as is known, the single has always been supreme for high performance, even in much larger sizes of engines than those we are concerned with. However, it is one thing to produce power, and another to use it efficiently; and a very great advantage in this respect is held by the twin, as it does not waste power in vibration. The superior balance of the flat twin is a real virtue, and must be experienced to be believed. I have not tried to balance pennies on the Craftsman Twin, but it can be held in the hand when revving flat out, without the least sensation of vibro-massage! In other respects, its performance is well up to expectations, but at this stage I prefer not to make any sweeping claims; let the engine speak for itself in due course.

And now, readers, I hand over to you yet another addition to my many and varied designs of model petrol engines, in the confidence that you will do full justice to it. I know that many sets of castings for these engines are already in circulation, and some of them may even now be finished or nearing completion. To these and all subsequent constructors, I express the wish that they will find as much interest in building and running the engine as I have done in developing the design—which is saying a good deal.

An Exhibition at Andover

AT the exhibition of the Andover Society, held on Saturday and Monday, March 27th and 29th, over 3,000 people paid to see the 130 models displayed by Andover and other societies affiliated to the Southern Federation of Model Engineers. Transport difficulties prevented some societies assisting, but in spite of this a grand variety of models were on view and greatly admired by all who saw them. Special attention was focused on the models working by compressor, chief of these being Mr. Smallbone's (Silver Medal) Portable and Mr. O. T. Wick's (Bronze Medal) Showman's Tractor. Mr. R. Doughty was crowded out with youngsters with his "OO" gauge layout, and George Crouch cracked their eardrums with his 5.5-c.c. "Kestrel" i.c. engine. Bournemouth's cosmopolitan entries, Basingstoke's agricultural effort, Newbury's engines and instruments, Fareham's ships and planes and Lymington's yachts, all vied with one another for exquisite workmanship, colour and variety, and worthy of mention was a collection of six models loaned by Mr. Lane of Liphook. Among other "visitors," to loan models, was Mr. L. Willoughby of Eastleigh and Mr. Cosgrave of Andover with $3\frac{1}{2}$-in. gauge and "O" gauge locomotives respectively.

Two outstanding efforts must be mentioned, Mr. Smart of Hayling Island with his 10-year old road tractor, toured the streets and byways of Andover, advertising the show, and his juvenile driver, John Lillington, was the envy of many interested youngsters. In spite of his 74 years, Mr. Smart performed marvellously and his efforts were so much appreciated that he was elected to honorary membership of the Andover Society.



Mr. C. Barnett's $7\frac{1}{4}$-in. gauge "Royal Scot" on passenger-hauling duty at the Andover exhibition

The major attraction, however, was Mr. C. Barnett's $7\frac{1}{4}$-in. gauge "Royal Scot." The locomotive (many saw this at the last exhibition as a "boiler"), worked the whole two days from 10 a.m. till 8 p.m. hauling 2,200 youngsters, without once being in trouble. Such hard work reflects great credit on the workmanship of her constructor, and so impressed Mr. Thurley of Newbury and Mr. Summerscales of Portsmouth, who judged the eleven entries for the Fuller Cup, that they had no hesitation in awarding Mr. Barnett the trophy. The Arts and Crafts section for schoolchildren was also a great success, and the winners are to be congratulated on their ingenuity and skill.

Our thanks are due to the ladies of the society who worked hard on the "door" and refreshments stalls, to the Compressor Gang who kept the "wheels" turning throughout, and to John Davis of Eastleigh who travelled from Eastleigh daily to drive the "Royal Scot" with Gordon Howell of the Andover Society, and to Mr. Westbury who "opened" the show in his usual forthright way.

Thanks are also due to the members of the society for their grand "all in" effort, and also the secretaries of the affiliated societies of the Southern Federation for their able assistance.

*Making Scale Ships' Fittings

Suitable for motor-yachts, cabin-cruisers, A.S.R.Ls., M.T.Bs. and other "light craft"

by W. J. Hughes

THE stemhead roller is the fitting at the bows over which the anchor chain or cable passes, and in the prototype is a casting, flush with the deck, with two webs between which the roller fits. The webs bulge inwards slightly at the top to give a fairlead effect.

Fig. 6 shows the model construction fairly well—the base-plate was filed from $\frac{5}{8}$ in. $\times$ $\frac{1}{4}$ in. section brass bar, a parallel tongue being left to facilitate gripping in the vice.

Slots were sawn and filed into which the webs were to fit; the latter were filed up from 16-gauge brass and silver-soldered into the slots. The roller is a bit of simple turning, and the spindle 20-gauge wire, with "nuts" drilled and filed up from $\frac{1}{8}$ in. diameter wire. The holding-tongue was then cut away, and the webs sweated on as the whole was tinned.

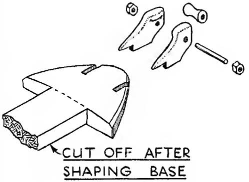


Fig. 6. *Component parts of the stemhead roller*

Deck Cleats

These do not show on any of the photographs, but are simple tee-shaped cleats with bases. There were two only, and Fig. 7 gives a fair idea of their construction. A strip of 20-gauge brass was drilled with two holes through which stubs of 18-gauge wire were pressed. The pointed ends of the wire protruded below the base-plate to form fixing dowels.

A vee-groove was filed across the tops of the uprights, in which a short length of 18-gauge wire was laid. After silver-soldering at the four joints, the cleats were cut in two and cleaned up, the bases being filed oval, following which they were tinned and fixed to the deck, the dowels being pushed into holes slightly smaller in diameter than themselves.

*Continued from page 421, "M.E.," April 22, 1948.

Cowl Ventilators (Photos 1 and 3)

Cowl ventilators are such a prominent feature on any boat to which they are fitted that their appearance can make or mar that of the whole boat—I have seen models whose vents were veritable eyesores. It is, therefore, worth while taking extra care with them. There are slightly varying shapes in the prototypes, owing to different methods of fabrication, but the method about to be described gives realistic results for one particular shape.

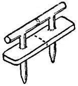


Fig. 7. *Two cleats before separating. Note fixing dowels*

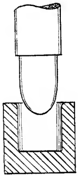


Fig. 8. *Punch and die for ventilator cowls*

With this method a lathe is desirable, but not essential—I have done it without in the days when I had no lathe. The punch had to be filed up instead of being turned, and the female die was a hole bored in hard wood, with a brace and bit, instead of being bored in brass.

On the model A.S.R.L., the vents consist of a cowl with beaded edge, a tubular stem or stalk, and a flange, below which the stem extends into a hole in the deck. In passing, the tyro may not know that where the diameter of a cowl vent (say "9 in. cowl vent") is shown on a drawing of a prototype, this is the diameter of the *stalk* or air-passage and *not* the cowl. With mushroom vents, the given diameter usually refers to that of the internal tube (or air passage again), and *not* the overall diameter. Confusing, isn't it?—but then it's no worse than calling an anchor-chain a "cable" or a rope a "sheet": both common in maritime nomenclature.

In my case, the punch was turned from $\frac{5}{8}$-in. brass rod to 9/16 in. diameter, and the end was hand-turned to shape with a graver—but don't be afraid to use file and emery cloth, however "unprofessional" it may be! Note the ample length of the 9/16 in. diameter part, which is necessary because the cowl must be punched deeper than its finished depth (Fig. 8).

Before removing it from the chuck, the punch was centre-popped against No. 1 jaw so that it could be put back to run true, later on.

The female die consisted of a short length of $1\frac{1}{4}$-in. diameter brass, bored with a $\frac{5}{8}$-in. diameter parallel hole, which allows for the thickness of the metal of the cowl between punch and die. It is not necessary to shape the female die to match the punch, as the metal will naturally "draw" to the shape of the latter. The inside top edge of the die should be rounded slightly to allow the metal of the cowl to draw over it more easily and to prevent cutting (Fi . 8 also).

the end of a stub of $\frac{1}{4}$-in. diameter brass rod, and was held in the tailstock drill-chuck. The punch was set in the three-jaw to run truly, and having cut off with shears the waste flange from a cowl, the latter was mounted on the rounded end of the punch. The female centre was brought up, oiled, and pressed against the cowl with just sufficient force to allow the latter to be "driven" by the punch, while light cuts were taken with a R.H. knife tool (Fig. 10). Following this, the tailstock was drawn away, and the outsides of the cowls polished with emery-cloth.

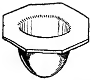


Fig. 9. Ventilator cowl after punching, but before trimming

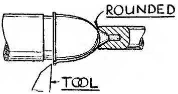


Fig. 10. Trimming the cowl. Note female centre

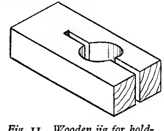


Fig. 11. Wooden jig for holding tube in vice without crushing

Making the Cowls

For the cowls $1\frac{1}{2}$ in. squares of 26-gauge soft (annealed) copper sheet were cut, and their corners snipped off to leave octagons. One of the pieces of copper was placed on top of the die, and the punch having been placed centrally on the blank was struck with the hammer. As with each blow the punch drove the copper deeper into the die, so the edges of the blank rose, and after two or three blows were tapped down again. After a few more blows, the blank was so work-hardened as to have no more "give,"

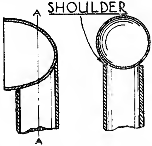


Fig. 12. Section through vent cowl. Note square shoulder left in hole by filing, which must be removed before soldering

and its edges had risen again and were beginning to wrinkle up, indicating that it was ready for annealing. It was therefore laid aside and the remaining blanks taken to the same stage.

The annealing was done by heating to red with the bunsen, and quenching in water—though a pickle bath would quench and clean at the same time. The sequence of punching and annealing was repeated thrice more, when the cowls were deep enough. They now appeared as sketched in Fig. 9.

A female centre was made by centre-drilling

Photo 3 shows the completed vents, the punch and die, the female centre, and some spare cowls.

The Stems

For the stems, pieces of $\frac{3}{8}$-in. diameter brass tube were cut off, and one end of each was filed with a half-round file to fit the curve of the cowl. To prevent squeezing the tube out of shape in the vice, a $\frac{3}{8}$-in. hole was bored through a scrap-end of wood, which was slightly tapered in breadth. A saw-cut having been made from the wider end, the tube was slipped into the hole,

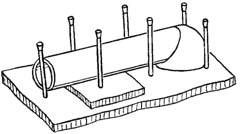


Fig. 13. Simple jig for holding ventilator while soldering

and the *wood* gripped in the vice. (Jig shown in Fig. 11.)

When the end was filed, the inside edge of the tube being square prevented the cowl fitting properly (see Fig. 12), and this was remedied by scraping the shoulder away inside the tube with a triangular scraper—it could have been removed with a round file, of course.

Another small jig was made to assist in soldering stem and cowl together. Seen in Fig. 13, it consists of a wood block to which a piece of asbestos pulp-board was tacked. (Sketch shows the asbestos only.) Another bit of asbestos

supported the stem at the correct level, and thin panel-pins held the cowl and stalk in their correct relative positions. The joint was then sweated, and a small fillet of soft solder run in so as not to leave a hard angle between the two.

Incidentally, it can be said definitely that when making cowl vents in future, a similar jig will be used, but the joint will be *silver-soldered*, for reasons which will be apparent shortly.

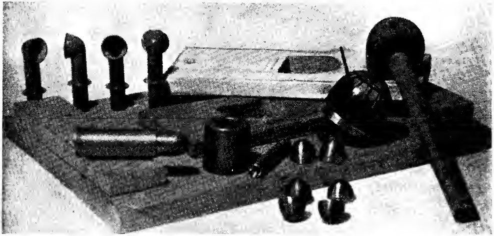


Photo No. 3. Some of the fittings, and the jigs

The Beading

The next job was to sweat a piece of 30-gauge copper wire round the edge of the cowl. Both wire and edge were painted with solder-paint, and one end of the wire was clipped in position, using a small split - pin as a clamp (Fig. 14). The wire was wrapped half-way round the cowl, keeping a slight tension on it, and "tacked" in two places with small blobs of solder. The split-pin having been removed, the wire was wrapped right round, and tacked in two more places, the last near the starting end of the beading. Now the surplus wire was cut off, and the two ends held in position with a small sliver of wood while they too were tacked.

It was then that the "fun" started. A little extra solder was picked up on the soldering-bit, and run round the beading, partly to secure it firmly, and partly to "fill in" the gap (Fig. 15). Unfortunately, however, whilst doing this, there is a tendency for the cowl to fall off the stem, and when this has happened two or three times one is apt to start muttering under one's breath!

That is the reason for the decision to silver-solder this joint in future, but in this case I eventually remembered a tip given me years ago—to place a damp cloth pad against the joint which has already been soldered, to prevent it being unsweated, and this worked well.

After sweating on the beading, the stalk of the vent was gripped in the three-jaw chuck, with the cowl inside the chuck-body, and a $\frac{5}{16}$-in. drill was run "up the flue." The drill was fed carefully, and no trouble was experienced as it broke through into the cowl. Removing the vent from the chuck, the sharp edge of the hole was pared away with a scraper.

The Flanges

In actual prototype practice, the base flange carries a spigot, on to which the vent stalk fits, so that it may be rotatable to catch the breeze, if desired. In model practice this is not necessary, as a rule.

For the base flanges, a $\frac{3}{8}$-in. hole was drilled centrally up a stub of $\frac{5}{8}$-in. diameter brass rod and the flanges were parted off one by one to a thickness of 3/64 in., having chamfered the outer

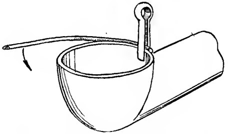


Fig. 14. Split-pin used to clamp "bead" in position during soldering operation

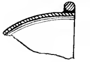


Fig. 15. Showing how gap at each side of round wire beading is filled in with solder

edge of each. They were then sweated on to the stalks at the correct distance below the cowls.

The protruding part of each stalk fits into a $\frac{3}{8}$-in. hole bored through the deck into a block of wood cemented to its underside—the deck itself is only 1 mm. thick, which would not afford adequate support for the ventilator.

(To be continued)

A $1\frac{1}{4}$-in. Scale "Burrell" Engine

by A. J. Rowlands

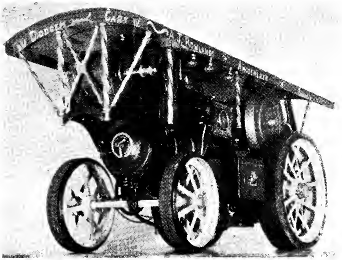


Photo by] [*C. Payne*

A three-quarter front view of the scale model traction engine

HAVING had the opportunity of looking over a Burrell traction, I decided to build a working model. A scale of $1\frac{1}{4}$ in. to 1 ft. was chosen and no time was lost in making drawings, and a start was made on the model. The main dimensions are: H.P. bore, $\frac{3}{4}$ in.; L.P., 1 in.; stroke, $1\frac{1}{2}$ in.

The rear wheels are $8\frac{5}{8}$ in. diameter over the tyres, front wheels $5\frac{1}{2}$ in. Sh: is fitted with two speeds, also differential gear. There are two generators; an injector and pump look after the water supply. The mechanical lubricator is in the cab, where it is easily accessible.

Her working pressure is 80 lb. per sq. in., and, up to the time of writing, she has pulled $3\frac{1}{2}$ cwt., but is capable of more.

A total of 1,200 hours was spent in the building, and I might mention that I have had no training of any description. I hope the photos will be of interest to readers.

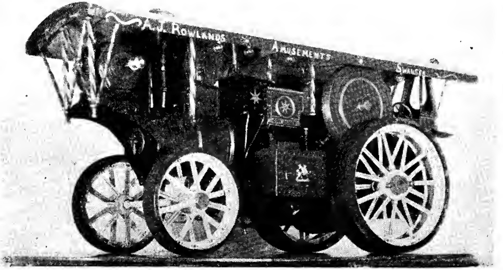


Photo by] [*C. Payne*

A near-side view of Mr. Rowlands' scale model "Burrell"

A $3\frac{1}{2}$-in. Gauge L.M.S. Class 5 Loco.

by "L.B.S.C."

IN fulfilment of a promise made some time ago, that I would offer something that would prevent the tools and equipment of $3\frac{1}{2}$-in. gauge locomotive builders lying idle, I now have pleasure in introducing you to "Doris of the L.M.S." Nice young lady, isn't she ?—but she hasn't half caused some stirring of grey matter during the last three weeks or so, time of writing.

The locomotive is a fairly close copy of the full-sized Class 5 mixed-traffic engines, which in your humble servant's opinion (and in that of a good many "high-ups" in the locomotive world) are the best "all-round" engines running on British metals today. They are equally at home on a 1,000-ton coal drag, an ordinary loose-coupled freight (one of them has just gone by, on the daily through mixed coal-and-goods service to Three Bridges), a fast "stopping" train, where their rapid acceleration is of the greatest value, or an express passenger train needing a maximum speed of 90 miles per hour on favourable parts of the road; and the way they can march over the Pennines or climb the Cumberland hills, is just nobody's business.

Brief Specification

The principal dimensions of the $3\frac{1}{2}$-in. gauge engine correspond to the 4-ft. $8\frac{1}{2}$-in. version in proportion to size; the details vary, because, as I've often remarked, you can't "scale" Nature. I might remind all beginners that this engine, like all other "Live Steamers," is intended for real hard work, and is arranged accordingly. The main and bogie frames are $\frac{1}{8}$-in. mild-steel plate, with buffer and drag beams made either from stout angle or castings. The main frames are stiffened up by the bogie bolster, also a casting, and the cross-stay carrying the pump. Hornblocks and axle-boxes are the same as "Molly," "Petrolea," and other engines described in these notes; this brings in "stock" castings, cutting down both price and labour. Coupled wheels are $4\frac{1}{2}$ in. diameter, the equivalent of 6 ft., but the bogie wheels are slightly smaller in proportion to size ($2\frac{1}{4}$ in.), as we have to use proportionately deeper flanges, which would bring them oversize if the treads were "scale" diameter, and so reduce the clearance.

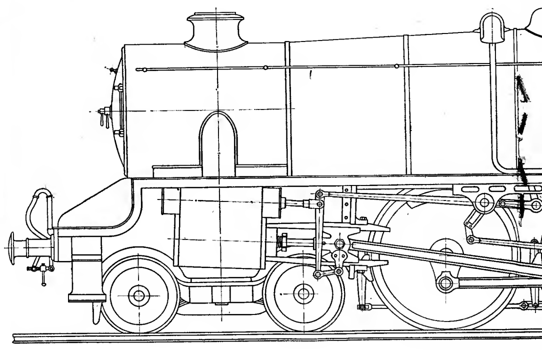
The cylinders are correct piston-valve type, one and five-thirty-seconds inches bore (I've written that in full because the printers set it up as though it were 15/32 in.—you'd be surprised the number of letters I have received telling me I've made mistakes in measurements !) and $1\frac{3}{4}$ in. stroke, which corresponds to the $18\frac{1}{2}$ in. by 28 in. of the full-size job; but you can bore to $1\frac{3}{16}$ in. if the castings will stand it. The boiler will, I might add ! The piston-valves are $\frac{5}{8}$ in. diameter, corresponding to big sister's 10-in. valves. I fancy we have about smashed up the old hoary idea about piston-valves being "impracticable" on little engines; my "Fernanda" is fourteen this year, and hers are as steam-tight today as when she was "born." Beginners may be surprised to learn that piston-valve cylinders are easier to make and fit than slide-valve cylinders. There are no steam-chest and cover joints to make, no array of studs around a flat steam-chest, no laborious port-face and valve truing-up jobs, and no valve-sticking-off-the-face trouble when the engine is at work. There are also no valve-spindle glands to keep tight; these are a prolific source of steam leakage on many engines, and if tightened too much, they put strain on the valve-gear.

Walschaerts' valve-gear is used, with box links carried by a small replica of the characteristic link girder of big sister. Eh—what's that ? No, I'm not offering a bunch of roses—nor a whisky-and-soda !—to Inspector Meticulous; it just happens that this type of girder suits young "Doris" very nicely, and so she uses it. She also has her full-sized relation's long combination-lever (the "new look" ?), but I have left out the valve-spindle guides, as they are not necessary in this size, and a fiddling job to make and fit, anyway. The light appearance of the whole valve-gear is retained without sacrificing any strength.

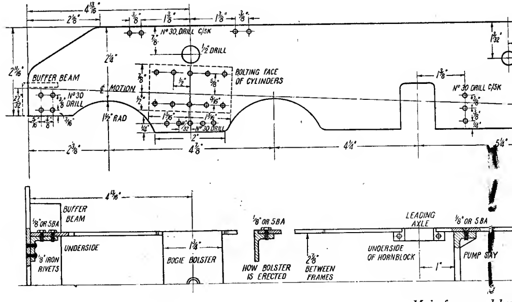
The boiler is a true L.M.S. type kettle, of "scale" diameter over the lagging of the full sized job, and is made from 3/32-in. or 13-gauge sheet copper throughout, except for the backhead and tubeplates, which are $\frac{1}{8}$-in. or 10-gauge. All joints are brazed or Sifbronzed, except the tubes which are silver-soldered. The firebox and tube arrangement will be to my usual specification, with plenty of superheating surface; high superheat and mechanical lubrication are two of the factors contributing to the success of real "Live Steamers." A grid regulator and top feeds are included, supplied by one eccentric-driven pump and one injector, with a tender hand-pump as emergency stand-by. All fittings and mountings will be to my usual tried-and-proved "standards," and I will also give, all being well details of steam brake, working sanders, and other oddments. The tender will be a one-sixteenth copy of the standard L.M.S. tender, with the usual accessories, and working hand brake. Well, I guess that is enough about generalities; let's get down to the job, and I hope to be able to keep it running parallel with "Maid" and "Minx" in the same way as "Juliet" kept company with "Hielan' Lassie."

Main Frames and Buffer Beams

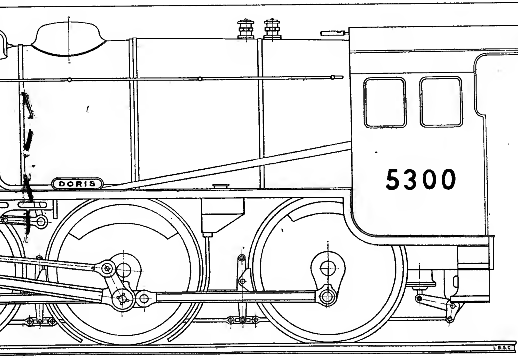
Two pieces of $\frac{1}{8}$-in. mild-steel plate 28 in. long and $3\frac{1}{4}$ in. wide will be needed for main frames. Either bright or blue will do; but if you use the former, it should be of soft quality, not the hard-rolled kind, which assumes a bow shape as soon as the openings for the hornblocks are cut out. By this time, followers of these notes won't need any detailed instructions about marking and cutting locomotive frames; just mark one out, drill a couple of holes through both, rivet tem-



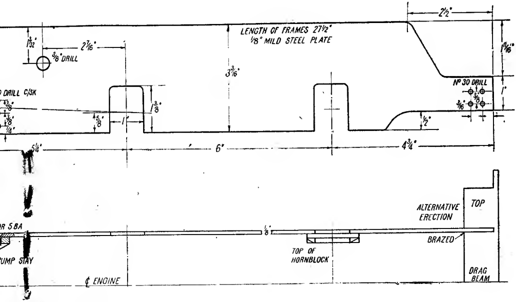
3½-in. gauge L.M.S. C



Main frames and ho



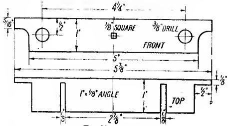
L.M.S. Class 5 locomotive



es and how to erect them

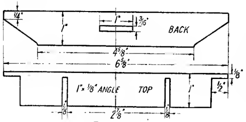
porarily together, and get busy with saw and file.

When marking out, be careful about the holes for cylinder fixing studs, and the hole for the reversing-shaft bush. First get the centre-line of motion; make a centre-dot $\frac{5}{8}$ in. from the bottom of the frame, on the centre-line of the driving hornblock opening. Next, at the extreme front edge of the frame, at 27/32 in. from the bottom,



Buffer beam

mark another point, and scribe a line from one to the other. This gives you the centre-line of motion; and from it, the position of the cylinders is set out, as shown by the dotted lines on the drawing. The centre of the cylinders is $4\frac{13}{16}$ in. from the front edge of the frame. The five upper stud-holes are $\frac{5}{8}$ in. above centre line, and the lower ones $\frac{5}{16}$ in. below it, all at $\frac{1}{2}$-in. centres and drilled No. 30. The five holes right at the bottom are for the screws attaching the bogie bolster. The $\frac{1}{2}$-in. hole for the exhaust-pipe is on the vertical centre-line of the cylinders, and $\frac{7}{8}$ in. from the top of the frame. The "two-twos" at the top are for the smokebox saddle screws. The three holes behind the hornblock opening of the leading coupled axle are for the screws holding the pump stay. The $\frac{3}{8}$-in. hole between leading and driving horn openings is for the reversing-shaft bushes, and the position of this is important; it should be $2\frac{7}{16}$ in. ahead of the vertical centre-line of the driving axle and one and three-thirty-second inches below the top of frame. The holes at either end are only for screws holding frames to buffer- and drag-beams, so no "mike measurements" are called for.

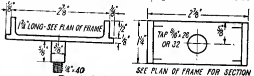


Drag beam

The buffer- and drag-beams may be made from 1-in. by $\frac{1}{8}$-in. angle, or from castings. Steel angle is best, but brass would do at a pinch. Note, the buffer-beam is shorter than the drag-beam, and the vertical parts of both are finished off to fancy shapes, as shown. The most important thing is to get the slots for the frames absolutely dead square with the beams, otherwise the frames won't line up properly, and you'll have one side of the engine running ahead of the other. If a $\frac{1}{8}$-in. saw-type milling-cutter isn't available to cut the slots, and hand work has to be made do, use the vice-top to guide saw and file. If you have a cutter, mount it on an arbor either between centres or in the three-jaw, former for preference and clamp the beam under the slide-rest tool-holder parallel to the lathe bed. Feed straight in, using slow speed and plenty of cutting-oil.

Rivet a piece of $\frac{3}{8}$-in. by $\frac{1}{8}$-in. angle flush with the inner edge of each frame slot, a shown in plan view. I always jam a scrap bit of $\frac{1}{8}$-in. steel in the slot, and clamp the angle to it with a toolmaker's cramp, if I use this method of frame attachment, whilst drilling the holes for the rivets, and putting them in. When all four angles are fixed, the whole issue can be erected as described for the "Maid" and the "Minx," laying the frame upside down on your lathe bed, seeing that the top edges touch the bed full length, and adjusting the beams so that they are exactly the same distance from the bed at each end of the frames, and exactly parallel all ways. Then drill and tap the screw-holes, and everything should be Sir Garnet.

If preferred, the frames can be Sifbronzed or brazed into the slots in the beams—my favourite method now—and no angles are needed; but take the same strict caution as before, to have the frames parallel and the beams square. I have already described how to clamp the whole issue



Bogie bolster and pump stay

with a couple of packing-blocks between the frames, to prevent them going out of parallel when heated; so need not repeat here. Before brazing, however, it is advisable to fit the hornblocks, as this job is easier with the frames apart; besides, the hornblock jaws are more easily trued up when the frames are temporarily bolted together "inside out," as the kiddies would say.

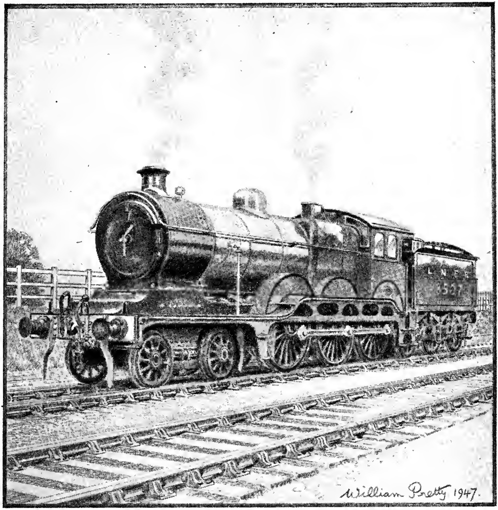
If cast beams are used, there will be lugs cast on, for attaching to frames; and the whole lot should only need cleaning up with a file, and the slots made for the frames as mentioned above.

Bogie Bolster and Pump Stay

Little space need by used in describing these, as they are both similar to the "Maid of Kent's," only smaller; the drawings give the sizes. Castings will be available for both, and machining as described for the "Maid." Hold the bolster in the three-jaw by the chucking-piece opposite the pin; turn the latter and screw the end to given sizes, then face the flat surface, cutting off the chucking-piece when through. If you have a small machine-vice which can be attached to the lathe saddle or boring-table, the casting could be held in that, at the correct height, and traversed across an end-mill or home-made slot-drill not less than $\frac{1}{2}$ in. diameter, held in three-jaw, which would clean out the rebates each side, so that the casting fitted nicely between frames. Lucky

(*Continued on page* 463)

L.N.E.R. No. 8507



THE illustration herewith is reproduced from another of Mr. W. Pretty's attractive pencil-drawings; it is based on a photograph supplied by The Locomotive Publishing Co. Ltd., and its depicts L.N.E.R. 4-6-0 express passenger engine No. 8507. Built in 1912, to the design of Mr. S. D. Holden, No. 8507 was originally No. 1507 of the old Great Eastern Railway, and was one of the first ten engines of that company's well-known "1500" class of express passenger locomotives; the last of the class to be built, No. 1580, was put into traffic in 1920, by which time no fewer than 81 of these fine engines had been constructed.

After the grouping of the railways in 1921, the G.E.R. locomotives became the property of the London and North Eastern Railway, and were all renumbered by the adding of 7,000 to their former numbers; Nos. 1500-1580, therefore, became Nos. 8500-8580, and were officially classed "B12." In 1927, the late Sir Nigel Gresley began to reconstruct these engines with larger boilers having round-topped fire-boxes; but, for various reasons, this scheme was not completed, only fifty-four engines being dealt with, leaving twenty-seven in their original condition. The scrapping of the latter has begun, four engines having been broken up recently.

In 1946, the L.N.E.R. introduced a renumbering scheme for its locomotive stock, and under it the "B12" class reverted to their old G.E.R. numbers, becoming once more 1500 to 1580, inclusive. Mr. Pretty's drawing shows No. 8507 in her original condition, except for the L.N.E.R. style of painting.

*Building a $3\frac{5}{8}$-in. Centre Lathe

by E. W. Brennand

IN machining the bed the procedure adopted was first to plane the base as flat as possible and on release from the machine this base was scraped true to correct any errors due to distortion caused by the holding-down bolts. This gave a true surface from which to set off the remaining operations. The casting was then set up on this base, the inverted V's roughed out and the back shears planed up. The undersides of both front and back shears, also their vertical faces, were planed at this setting; at the same time the undercut surface between the two shears which carries the tailstock clamping plate was dealt with.

The job was then turned end for end on the planer table, and the headstock platform was then surfaced and the slot for the headstock tenon cut out. The casting was then clamped by its base to two large angle-plates, set up carefully on the planer and the gearbox seating machined up. The whole assembly was then moved bodily along the planer bed so that the lead-screw bracket seating and the rack-seating could receive attention. The necessity of moving the job between these operations arose, of course, through the limitations imposed by the stroke of the machine.

All this rough machining was taken to within a 1/32-in. or so of finished size. The casting was then left to season for a number of months, but no apparent distortion took place. The final planing operations were then taken in the same sequence as the roughing cuts.

Scraping a bed of this description is not easy. The two Vs must be quite parallel if the tailstock is to line up correctly in all positions, and the V-ways and the flat slideways must all lie in the same general plane. As it turned out, very little trouble was experienced in the scraping, and the comparative ease with which this was accomplished can be ascribed both to the accuracy of the planer used and to the meticulous care taken in the finishing cuts.

The Saddle

This was also cast in Meehanite, and the casting was obtained at the same time as that of the bed. It has extension wings at the front and rear, giving long bearing surfaces on the ways of the bed. This results in a sweet movement, with an absence of rock, this feature being enhanced by the single narrow guide, the front V of the bed, and the fact that the drive to the saddle is located almost directly under this guiding surface. There is, therefore, very little couple force tending to twist the saddle round on the bed. Adjustable gib strips are fitted below the shears, both back and front, to counteract any tendency for the saddle to lift.

The most important point in machining the saddle was to ensure that the under V matching the bed was located exactly at right-angles to the sliding surfaces on which the cross-slide moves.

A moment's thought will show that if there is any error in this respect the lathe will not face truly. In any machining job where two or more surfaces have to occupy a certain relative position to each other, the way to set to work is first to prepare a reference surface from which to set out the remainder. First of all, the casting was rough machined and left to season. The writer makes this his invariable practice where castings are concerned. With good castings of good design, with the metal well distributed, serious warping seldom occurs; Meehanite is specially good in this respect. It is well worth while, however, to run no risks, and a period for seasoning, if it can be given, should be allowed.

After seasoning, the following procedure was adopted. Having decided on the rear vertical face of the saddle as the reference face, this was scraped up dead flat. A precision square was clamped by its stock to this surface, and the job was then set up on the planer table so that a dial indicator (held in the tool-post) reading against the blade of the square showed the latter to be parallel to the stroke of the machine. In this position the surfaces guiding the cross-slide were finish planed. These surfaces were therefore at right-angles to the reference face. The square being removed, the casting was turned over and set so that using the dial indicator against the reference face the latter was parallel to the machine stroke, and at this setting the V bearing on the corresponding V of the bed was finish planed, as also was the surface sliding on the rear shear. A little thought will show that this method of machining secures the desired result as regards the positioning of the cross-slide guides with the V groove locating on the bed. Subsequent tests showed the error in the cross-slide movement to be as little as 0.0005 in 4 in., a matter readily put right by scraping.

Felt boxes are fitted to the ends of each saddle wing and the felts are arranged to wipe over both the upper and under surfaces of the shears. Oil holes are drilled in the saddle wings to communicate with the felts, the holes being closed by small screwed plugs. The sliding surfaces of the saddle and bed are thus continuously lubricated when in operation, the felts retaining a supply of oil for a prolonged period.

The Cross-slide

This is made of cast-iron containing a small percentage of nickel. Meehanite was not available in a reasonable time when the pattern was made after the war ended. However, nickel iron gives a nice dense casting readily machineable, though harder than ordinary cast-iron, and is resistant to wear. There is nothing very special in the design, with the possible exception of the T-slot running transversely at the rear of the slide. This slot is for the purpose of secur-

*Continued from page 396, "M.E.," April 15, 1948.

ing a rear parting-tool holder—a very useful fitment on any lathe if it can be accommodated; it also provides a means of attaching a travelling steady. When the latter is in use the cross-slide is locked, the top-slide being swivelled round and used to put on the tool feed.

Adjustment to the slide is provided by a solid gib-piece (cast-iron)—a type superior to the thin strip so often seen in small lathes, though not quite so good or convenient as a properly fitted taper gib.

cross-slide index when the top-slide is swivelled round. It also gives greater clearance between the handle and the tailstock when working close up against the latter—many lathes are very awkward in this respect. Again, the screw is of high-carbon steel with a phosphor-bronze nut. The micrometer index is fitted to the screw, not to the spindle on which the handle is set, and consequently the readings are not affected by any pitch error that might be present in the gears.

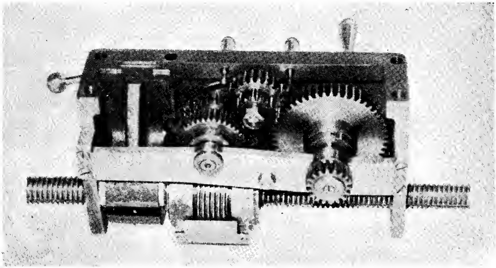


Photo No. 3. Interior of apron

The top surface of the slide is bored to receive a corresponding stub on the top-slide. This bore has an undercut groove in which are located three clamping pads (each being a segment of a flat ring) which are tapered on their inner circular edge. The taper portion engages with a tapered groove in the top-slide stub and when the pads are tightened up (by three socket-head grub-screws equally spaced round the seating) they lock the top-slide by drawing it hard down on its seating on the cross-slide. A protractor scale reading to 90 deg. each side of zero is provided for setting the top-slide to any desired angle.

The cross-slide screw is of high-carbon steel, having a square thread, 10 t.p.i., the nut being of phosphor-bronze. Special care was taken to keep back-lash down to the minimum. The screw is fitted with a micrometer index, having well-spaced divisions reading in thousandths, the divisions being large enough to enable one quarter of this dimension to be estimated readily. The index is held by an adjustable friction grip so that it can be set in any desired position.

The Top-slide

The feature of this slide is the geared drive between the operating handle and the screw. This enables the handle to be set above the normal position and thus permits it to clear the

The method of locking this slide to the cross-slide has already been described in dealing with the latter. Nothing further need be said about the top-slide, except, perhaps, to mention that the Willis type tool-post shown is not one favoured by the writer. It was taken from the original lathe and, in fact, since the photographs were taken a tool-post of a different pattern has been put in hand.

The Gearbox

It would be in logical order to deal with the apron as the next item, but as some of the machining of this depended on the positioning of the gearbox and leadscrew bracket, these two will be dealt with first. The box is shown in Photo. No. 2; it was a tricky piece of work. Before describing briefly how it was made, a few general remarks about the box may be desirable. As most readers will know, a quick-change box of this type, in its elementary form, carries two shafts, one of which is driven from the main gear train meshing with the lathe spindle, while the other is connected to the leadscrew. The first shaft is keyed throughout its length and carries a pinion which slides along it. This pinion has extended hubs carried in a bracket which is free to revolve in a limited arc round the shaft centre line. This bracket carries another pinion, a "pick-off" gear, which meshes with the first and which,

by sliding the bracket along the first shaft, can be brought into mesh with any one of a cone of gear wheels which are keyed to the second shaft. The bracket has an extension arm protruding through the front of the box, and this arm carries a spring-loaded plunger which registers with a series of holes in the face of the box and provides for the correct meshing of the pick-off pinion with the selected gear.

The box fitted to the lathe has a cone of seven wheels cut in mild-steel, 18 D.P.; with a wheel of 22 teeth on the cluster gear spindle of the headstock, seven threads from 20 t.p.i. to 40 t.p.i. can be cut. With a 44-wheel as driver a second series of threads from 10 to 20 t.p.i. is available, the 20 being duplicated. Thus, with only one change of driver, thirteen different pitches of thread are available. Similarly, using the self-acting feed, thirteen different ratios of feed are obtainable, the first series ranging from 0.0035 in. (per revolution of the lathe spindle) to 0.007 in. and the second from 0.007 in. to 0.014 in.

The convenience which this box affords in the matter of screwcutting, without the bother of changing a train of wheels, and the immediate change from screwcutting to power feeds, is a matter which can only be appreciated to the full by those who have used a lathe fitted with an arrangement of this nature. Larger commercial lathes have supplementary ratios fitted to the gearboxes, but in the lathe under review there was not sufficient space available to fit a box having this refinement. Recourse was therefore made to the expedient of changing the driving wheel on the headstock when necessary. To facilitate this, the bracket carrying the intermediate wheels is provided with locating plungers which give a fixed position of the bracket for each wheel that it may be required to use as the driver. Correct meshing of the wheels is thus secured automatically without waste of time. Further, the cluster-gear spindle is provided with a spring-loaded slotted retaining washer which enables the driving wheels to be changed very rapidly, no screws or nuts being required.

The making of this box presented one or two problems. The leadscrew of the lathe must be properly aligned in both the horizontal and vertical planes with the ways of the bed. Similarly, as the driven shaft of the box is virtually an extension of the leadscrew, it, too, must be correctly aligned. The box has an open top to which is screwed a cover plate, and this top face of the box was used as a reference face from which to machine the back face (seating against the lathe bed) and the holes for the two shafts. First of all then, this top face was machined and scraped flat. The box was then mounted by this face on the miller table and the back face surfaced by means of a facing cutter. The job was then mounted on the boring table of the Exe lathe, suitable packing blocks being placed between this back face and the table to bring one pair of holes (cored out in the casting) to lathe centre height. The dial indicator was then used to set the top face of the box dead in line with the lathe axis, and in this position the holes were bored out, using a boring-bar between centres. By similar means the other pair of holes was machined and as, by the process used, both pairs of holes were parallel to the top and back faces of the box, they were also parallel to one another. It only remained to set the box on its seating on the lathe, setting the top face parallel in the horizontal plane with the lathe bed and to drill and ream dowel holes to give a positive positioning. The box was set in this way by means of a dial indicator secured to the lathe saddle and traversed across the top of the box. Subsequent tests showed the shafts to be aligned as required within very narrow limits.

The next job was the making and fitting of the two shafts. These are of medium carbon-steel and run in cast-iron bushes fitted to the holes bored out in the box as already described. These bushes are lapped out to a good finish and are fitted with felt pads to provide continuous lubrication. The pads for the top shaft are fed from lubricators through which oil can be forced from a gun when required, while those for the bottom shaft are fed from the supply carried in the box and which forms the oil bath in which the cone of gear wheels permanently runs.

The bracket carrying the pinions was next made and calls for no particular comment. The next problem then presented itself—how were the plunger holes in the face of the box to be properly positioned? This was solved in the following way. In the place of the pick-off gear in the bracket there was mounted a circular blank having an outside diameter equal to the diameter of the pitch circle of the wheel which it replaced. Similarly, on the gearbox shaft, instead of the cone of gear-wheels, there was mounted a series of blanks equal in outside dia. to the pitch diameter of the gears they represented. Thus, by positioning the bracket so that the blank it carried was in contact with one of the blanks of the shaft, the bracket was in the same position it would occupy when the proper gear wheels were in place and correctly meshed. The principle involved is, of course, that when a pair of gear wheels is correctly meshed the pitch circles of those wheels just touch.

In place of the plunger component a drilling bush was mounted in the extended arm of the bracket. The latter being positioned as described and clamped in place, a hole was drilled, via the bush, into the face of the box. The drill was driven by a flexible shaft and fed in by hand pressure, the drilling bush being long enough to give support to the drill and guide it correctly. A reaming bush was then substituted for the drilling bush and the hole in the box reamed to size. This procedure was repeated for each position of the bracket.

It might be thought that this method involved a tremendous amount of work in the making of the set of gear wheels and a corresponding set of pitch circle blanks. Actually, this was not so, since the blanks were made first and each blank was used from which to cut the actual gear-wheel of next smaller size. Thus, only two blanks were wasted—the one used in place of the smallest wheel on the cone and that used in place of the pick-off pinion in the bracket.

Lead-screw and Bracket

These two items can be dismissed very briefly.

The screw itself is of carbon-steel and has eight threads per inch, Acme form. It is splined to provide the means for securing the power feeds, leaving the threads for screwcutting only. The spline was cut in the Exe lathe, using a small milling cutter in a head mounted on a vertical slide, this method being necessitated by the fact that the only available milling machine had not a sufficiently long traverse to do the job.

The leadscrew bracket is fitted with lapped cast-iron bushes and takes the end thrust of the leadscrew in both directions, no thrust being taken at the gearbox end. The bracket was fitted to the bed by trial and error as regards positioning for the correct alignment of the leadscrew and is dowelled in position. The leadscrew is aligned to the bedways with an error of not more than 0.001 in. in 18 in. in either plane. A micrometer index is fitted, since, although the screw as a screw is not used for feeding the tool in normal work, it is very useful on occasion to have a means of moving the saddle along the bed to a definite measurement.

The Apron

The internal arrangement of the apron is shown in Photo No. 3. The half-nut is of phosphor-bronze, and this is attached to a cast-iron slide having V ways which slide in corresponding ways, machined in the body of the apron. The tightness of the slide can be controlled by a gib strip adjusted by grub screws in the apron end. A supporting pad below the leadscrew maintains the screw in correct alignment by preventing bending under the thrust imposed in operation. An adjustable stop limits the downward movement of the nut slide, thus controlling the depth of engagement of the nut with the screw.

Two brackets, dowelled in position, carry the worm, which has a fixed key engaging with the spline in the leadscrew. The worm is of steel and drives a worm-wheel of phosphor-bronze. The latter is mounted on a sleeve which carries a pinion on its other end. The drive is then taken through reduction gearing to the rack pinion. This drive is thrown in and out of engagement by a swinging arm having a plunger lock on the outside of the apron. This swinging arm carries a claw which engages with a projection on the nut slide and provides the interlocking arrangement referred to earlier, which prevents the simultaneous engagement of the nut and the power feeds.

The gear shafts are supported on their inner ends by the bar shown in the photograph, and all shafts are drilled up and provided with oil gun nipples for easy lubrication. Other nipples enable oil to be fed to the teeth of the gear wheels themselves. The worm runs in an oil bath which can be filled and drained without dismantling.

An unusual problem was presented by the necessity of the worm brackets being bored in strict alignment with the leadscrew, and the same requirement applies to the half nut and the supporting pad below it.

It will be seen from the photographs that the leadscrew passes through two holes in the ends of the apron, though it takes no bearing in them, there being considerable clearance. These holes were marked out for position and rough bored undersize, though just sufficient to pass the leadscrew through. All other machining to the apron having been finished, it was bolted in place to the saddle, the latter being in its working position on the lathe bed. A boring-bar was substituted for the leadscrew, being connected to the gearbox shaft at one end and running in the leadscrew bracket at the other. A pulley driven by a belt revolved the boring-bar and the saddle was moved along the bed by coupling it up to the tailstock barrel (the tailstock had been made at this stage). Thus, the holes in the ends of the apron were bored in line with the axis of the leadscrew. It was not possible to bore out the worm brackets and the rest by this means, due to their inaccessibility, so the apron was removed and the holes just bored were bushed up to support a boring-bar running between the centres of the Exe lathe. Then with the apron (open side upwards) being fed along the bar by means of the lathe saddle, the required holes in the brackets, etc., were bored truly in line with the holes in the ends of the apron, and consequently in line with the leadscrew when all was assembled. The bored nut blank was then removed from its slide, carefully centred in a four-jaw chuck so that its bore ran truly, and then screw cut.

(To be continued)

"L.B.S.C."

(Continued from page 458)

owners of milling-machines can do the job in a few minutes, with the casting in the machine-vice on the table and an ordinary end-and-face cutter on the arbor; but if no machining methods are available, you'll have to fall back on the good old file. A planer or shaper would, of course, finish the rebates as easily as a miller, holding the job in the machine-vice and using an ordinary knife tool in the clapper-box.

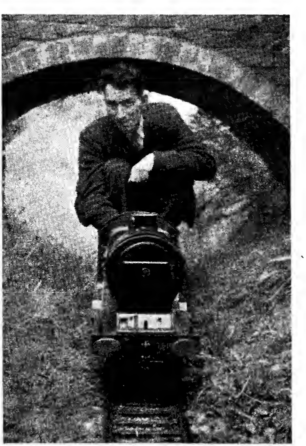
The pump-stay only needs cleaning up to size over both flanges, which can be done in the lathe, as described for the frame-stay on the "Maid"; milled or planed, if machines are available; or simply hand-filed, using a try-square to get the flanges exactly at right-angles to the main part. Drill a ½-in. hole in the middle, and tap it $\frac{9}{16}$ in. by 26 or 32 (or any other fine thread for which you have taps and dies), making sure the tap goes through square. Both bolster and pump-stay can then be located in the frames as shown in the plan drawing, and the screw-holes drilled and tapped, using those in the frames as guides; but don't erect them "for keeps" yet, as the frames have to come apart again for fitting the hornblocks.

Garden Railway Accessories

by H.J.H.

HAVE you observed how the work of others has a stimulating effect on your interests? As a garden railway enthusiast, the indoor layout, with its scenic effects and features enhancing operation, has probably left an impression, which after an indefinite period has emerged in the construction of an incline or other item, adding interest to the working of the line.

There are those, who consider themselves purely locomotive men, and aver that any track will serve. Admittedly, interest in steam locomotive operation is likely to increase, rather than wane, with the passing years. But, there are times when the need of a rest or change is felt. As interest in the railway, as a whole, should be maintained during such periods, they form the opportunity for installing useful accessories. Usually, these jobs occupy relatively little time, and one is enabled to return with animation to the locomotive sphere. Further, the broadened interests, reflecting the care and taste of the owner, may enable the lone worker to find a companion; whilst, for youngsters, the educational value of the installation is enhanced.



Garden railway harmony

Ground level tracks are those chiefly in mind; nevertheless, some items mentioned may prove an asset on other lines. For example, the "G.W.R."—the garden wall railway.

Very often the promoter or owner is a keen gardener, and is somewhat chary about introducing a railway within his domain. With careful planning there is little to fear, for often the results are an improvement generally. A gardening text-book will suggest curved paths leading to hidden charms. It is but a further step, in the realms of imagination and harmony, to devise features for both garden and railway, which will form pictures in themselves. A friend of the writer's, whose line was mentioned in the issue of January 23rd, 1947, made a cutting between the flower and kitchen gardens. A shrubbery heightened the effect, whilst overbridges between the two gardens augmented the railway equipment, and the accompanying picture shows the realistic touch to the railway scene.

Such bridges, together with those placed under the line, must be constructed with a liberal margin of strength to meet the loads they have to carry and to withstand natural deterioration. Cuttings should be made sufficiently wide at the base, as there is a tendency for them to close in and encroach upon the railway.

Tunnels are not likely to find favour, except as a possible carriage shed, owing to cost of construction and lack of materials. On a garden railway, they are usually made, and covered afterwards. However, it is possible to bore in the professional manner, as exemplified by a friend of the writer's, for a proposed 15-in. gauge line through a natural hill. Do not overlook drainage of the tunnel if you desire one. Remember, nothing was achieved without effort, but do not over-tax your powers. Lean on your shovel if you must!

It is surprising how many items noted during a trip over a full-size railway are not altogether out of place on our miniature ground-level projects. Accommodation works, generally to maintain "rights of way" in the matter of footpaths and so on. Fencing, walls, drains and

culverts. In fact, apparently everything except mechanical gates; and someone might even find a use for them. Very small things, such as mile posts, gradient boards, gang boards and relaying boards should not be overlooked. Whilst, platelayers' and fogmen's huts, can be used to afford weather protection to relatively delicate pieces of mechanism.

Some attempt may be made to introduce station platforms, and though very much simplified, the representation should not be crude. It is one of those items which should be designed to suit practical requirements. The same reasoning applies to the goods depot. Maybe, some readers will consider the foregoing suggestions avoidable outlay. Others will welcome them for the benefit of children's amusement and instruction. But let us continue.

In many cases, it is not convenient to run the locomotive directly into its shed, and means for its conveyance are needed, especially when working single-handed with a heavy engine. It is suggested that this transporter can also be used as a turntable. The idea is based on the girder-type turntables which, the model catalogues inform us, require no pit. In the case of a garden railway turntable-cum-transporter, no circular track is necessary, as suitable castors can be outrigged at the ends of the girder. These trail, in the usual manner, when the girder is towed to a prepared smooth surface and lined up with a raised track. When in position, a centrally-housed pivot pin is lowered to engage with a suitable pivot bearing, such as a tubular member embedded in the said smooth surface. Thence, the castor wheels roll over their path at the periphery, as though a circular track had been provided.

The raised track, mentioned in the previous paragraph, may conveniently accommodate the ash-pit, containing a receptacle to catch the falling ashes; or adapted so that the ashes may be swept out when convenient. A slightly inclined floor will assist rain water to drain away.

A coaling-stage or coal-drop is likely to prove inconvenient on most garden railways. But that should not preclude the use of a fuel container, in order that the place may be kept tidy.

An ample supply of good water is an important requirement. For furnishing the tender with supplies, a stand-pipe with a simple delivery valve is all that is desirable. An alternative, is a pedestal water-tank, or a tank on a brickwork support, under which oil and other stores could be accommodated. The point to bear in mind, is that, for this work, a large volume of water is more desirable, than water at high pressure.

The suitability of water for boiler use, is a major problem. This remark should not instil fear, but indicate a course of study for one of the "rest periods" mentioned. A useful source of supply is a butt, containing rain-water which has passed through a fine-mesh screen, on its way to the storage vessel. As this receptacle is likely to mar the immediate surroundings it is best kept away from the track. This, in turn, provides a good excuse for an undergound delivery-pipe to the control-valve. This pipe should be inclined and adapted for draining in frosty weather. If a permanent connection to the butt is not permissible, water, under certain conditions, may be syphoned therefrom.

Whilst on the question of water supply, reference may be made to a piece of apparatus, which to those living in the South of England, appears almost ubiquitous on lines radiating North from London—the water-trough. Readers, given a level section of track and whose locomotives can attain the required velocities, may care to fit pendent pipes to tenders, with a view to experimenting in the matter of picking up water whilst travelling. Two enterprising friends of the writer's, with a thirst for knowledge, checked the formula outlining the conditions. A car was driven at different speeds, through some flood water, whilst immersing a length of rubber hose as desired. This brought forth the scientific dictum "It didn't 'arf come out the top." Which in more sober moments, signified that was well with $2gH = V^2$.

Steam-raising and sand-drying equipment will, most likely, be found where the locomotive is stored, and need not concern us at the moment. There is, however, need for a waterproof yard lamp at the depot if night running is undertaken. A big thrill awaits those who have never undertaken this form of excursion. Cranes and capstans will not find favour at the depot, but some portable shear-legs might conceivably be put to good use. A few useful appliances, such as jacks and crow-bars, are worthwhile keeping on hand in a known and easily-accessible position. Finally, before we leave the depot, should you invite the public and others to ride your trains, it is wise to have an insurance policy within the office, and to test the boilers periodically.

Passing to the main line suggests the need for signalling apparatus. In this connection we have been fortunate, in recent years, in having presented in this journal, some authoritative articles on the subject of signals and signal-frames. Apart from semaphore or colour-light signals, according to choice, we can go further and include lamps, flags and fog-signals. In our own case, it is advisable to simplify construction as far as possible, and yet, endeavour to proceed on lines which would not offend the signal specialist. Semaphores of the G.W.R. or the M.R. type with round spectacle glasses are easiest to make, and may be very near scale size. Posts may be tubular or of angle-iron. The latter looks quite effective and facilitates the fitting of studs to carry arms, levers and lamps. The signal frame must be of ample size. Particularly is this the case when manually operating points, or pulling on a long strained signal wire. As we do not go in for elaborate junctions, it is worth while enjoying the facility and precision of interlocking, which is quite simple to install. It is but a further simple step to put the gear in a complete condition for night working.

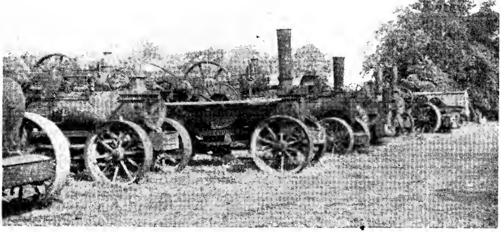
One could go on, almost indefinitely, with suggestions. Signal detectors, facing point bolt locks and rocking-bars, will all provide just "that something to do," should it be needed. Whether provided or not, such features do not prevent the owner making a trip single-handed. To offer the excuse that there is never more than one engine in steam is just evading the opportunity of perpetual interest.

A certain watchfulness, characteristic of all railway folk, will show the necessity of simple expansion and contraction devices. In signal wires, these may be just simple tension springs inserted in the pull wire, whilst for points, the rodding is passed through an eye on the end of the bell-crank, and supports on either side o the eye, a compression spring restrained between the eye and nuts on the rod. On a $7\frac{1}{4}$-in. gauge line, the late Mr. Mitchell used $\frac{1}{4}$-in. steel rods for point-rodding and 16-s.w.g. galvanised wire for signal wires.

If you can manage it, give pleasing and well-sounding names, to locations along your railway, introducing a spot of humour if you wish, but do not overdo this. It all adds to the fun ; but however complete you try to be in your venture, please spare us the sight of advertisements *en route*. If your railway is good, you'll get all the publicity you need, without advertising. Remember, Sir A. Heywood and James Spooner both achieved successful steam traction on a narrow gauge, and literally attracted the attention of the world.

Much that the writer plans for his own railway, if progress is possible in these difficult times, has been outlined above. In fact, to modify a radio travesty, "It's the Railway that keeps one going."

Editor's Correspondence



An Old Engine Graveyard

DEAR SIR,—With reference to the letter by "A.Y." of Cheltenham in the March 18th issue of THE MODEL ENGINEER on the "Old Engine Graveyard," the reproduced snapshot, taken last summer as I passed through, may be of interest to your readers.

Yours faithfully,

Kings Langley. P. W. STANLEY.

That Unusual Valve-gear

DEAR SIR,—Your correspondent, Mr. John R. Burdett, is perfectly correct in noting the affinity between the valve-gear which he describes (April 8th, p. 389) and the better-known form of Joy radial valve-gear. The gear illustrated is a true Joy gear, being in fact a form invented and patented by him.

Its use in British practice is extremely rare, indeed the only examples which the writer can recall at the moment were certain of the early Webb three-cylinder compounds on the L.N.W.R. It has the advantage of giving greater ground clearance than the normal type with anchor-link, hence its employment on locomotives having wheels of small diameter, as in the case of the industrial or light-railway locomotive seen by Mr. Burdett.

While kinematically equivalent to the ordinary Joy gear, it fully shares the disadvantages of the latter ; e.g., an undue stressing and weakening of the connecting-rod ; the severe friction of the die-block (especially in full gear) ; and the parasitic effects of the movements of the axle in the horn blocks. Apart from England, the only country in which the Joy gear found much favour was Russia, where a goodly number of locomotives in the last century were fitted with Joy gear of both the normal and return-crank types.

Trusting that these remarks may be of interest to Mr. Burdett and others.

Yours faithfully,

Andover. J. C. COSGRAVE.

Calorific Value of Fuels

DEAR SIR,—In the first paragraph of his letter in the March 4th issue, Mr. Dalziel points out that the products of combustion are the working fluid in an i.c. engine: arguments are then proposed based on air being the working fluid. There should be little doubt that the working fluid is the products of combustion, and it is immaterial, from the aspect of power output, whether these products are derived from the air or from the fuel.

In fact, the products of combustion bear no relation to the quantity of air used to support combustion. In my own calculations the volume of fuel passing into the cylinder with the air has been ignored. It is certain that the fuel does not enter the cylinder as a gas, but as a finely-divided mist and most likely complete evaporation has not taken place when the mixture is fired. A small quantity, of course, must evaporate and the heat required to do this is extracted from the cylinder walls and must be provided by previous combustion. The remainder of the fuel is vaporised during the burning process and the latent heat of vaporisation must be subtracted from the calorific value of the fuel.

During the b.h.p. measurements no extra cooling was used, since the object was to find the most suitable fuel to use with the particular engine. To supply extra cooling when using petrol would be unfair since under any conditions of cooling the relative temperatures of the engine would be the same. It is assumed that the signs of overheating observed by Mr. Cruickshank were due to lubrication failure; Mr. Cruickshank's engine is a two-stroke which normally runs hotter than a four-stroke. During my tests no such signs of overheating were observed, and extra cooling would be superfluous.

For the sake of calculation, let it be assumed, as a concession to Mr. Dalziel, that the fuel is completely vaporised at the carburettor jet and there is no cooling of the air during the evaporation of the fuel. All volumes are reduced to 0 deg. C. and 760 mm. Hg. pressure, and the figures are taken from Spiers' *Technical Data on Fuel*, and refer to fuels similar to those used for the tests.

The alcohol/benzol contains 77 per cent. alcohols and 23 per cent. aromatic hydrocarbons. Assume the alcohol to be ethyl alcohol and the aromatic body is benzene. The petrol is assumed to be octane. From the fact that a gas weighing 1 gm. mol. occupies 22.4 litres at 0 deg. C. and 760 mm. Hg. pressure, the volumes occupied by the alcohol/benzol and petrol can be calculated :—

1 gm. mol. of C_2H_5OH is 46 gm. and occupies 22.4 litres.

Similarly, 1 gm. mol. of C_6H_6 is 78 gm. and also occupies 22.4 litres.

1 kg. of the fuel contains 770 gm. of alcohol and this will occupy $\frac{22.4 \times 770}{46}$ litres.

$= 375$ litres,

and 230 gm. of benzene occupy $\frac{22.4 \times 230}{78}$ litres

$= 66$ litres

giving a total volume of $375 + 66$ litres $= 441$ litres or 0.441 cu. m.

1 gm. mol. of C_8H_{18} is 114 gm. and also occupies 22.4 litres as a gas.

$\therefore$ 1 kg. of petrol vapour will have a volume of $\frac{22.4 \times 1000}{114}$ litres

$= 197$ litres or 0.197 cu. m.

From the calculation it will be seen that completely vaporised fuel does not occupy the large volume that Mr. Dalziel would have us believe. Also, the heat available to do work is slightly in favour of the alcohol/benzol mixture. By a coincidence, the volume of the working fluid is the same in both cases, although considerably more air is used with petrol. In actual practice the fuel is not vaporised at the jet but considerably later, thus allowing a larger air charge when using alcohol/benzol fuel; this would also be increased by the refrigerating properties of this fuel.

Yours faithfully,

Runcorn. R. E. MITCHELL.

	Alcohol/benzol	*Petrol*
1 kg. of fuel requires	7.40 cu. m. of air	11.46 cu. m. of air
1 kg. of fuel as vapour occupies	0.44 cu. m.	0.20 cu. m.
$\therefore$ Vol. of mixture containing 1 kg. of fuel	7.84 cu. m.	11.66 cu. m.
The comparison must be taken on a volume basis and 1 cu. m. of air/fuel mixture will be taken as standard.		
$\therefore$ 1 cu. m. of mixture contains	$\frac{1}{7.84} = 0.128$ kg.	$\frac{1}{11.66} = 0.086$ kg.
Calorific value	7,170 kcals./kg.	10,500 kcals./kg.
$\therefore$ Heat liberated by 1 cu. m. of mixture will be	$7{,}170 \times 0.128$ $= 918$ kcals.	$10{,}500 \times 0.086$ $= 903$ kcals.
Total heat for complete evaporation	186 kcals./kg.	138 kcals./kg.
$\therefore$ Heat required to vaporise the fuel in 1 cu. m. of mixture is	186×0.128 $= 23.8$ kcals.	138×0.086 $= 11.8$ kcals.
$\therefore$ Heat available from 1 cu. m. of mixture	$918 - 23.8$ $= 894.2$ kcals.	$903 - 11.8$ $= 891.2$ kcals.
Vol. of waste gases per kg. of fuel	8.25 cu. m.	12.28 cu. m.
$\therefore$ Vol. of waste gases per cu. m. of mixture is	8.25×0.128 $= 1.056$ cu. m.	12.28×0.086. $= 1.056$ cu. m